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REVIEWS.

Correlation Essays, Archean and Algonkian. Bulletin of the U. S. Geological Survey, No. 86. Pp. 549, 12 plates. By CHARLES RICHARD VAN HISE.

IN order of publication, this is the seventh of the correlation essays originally planned by the survey for the International Geological Congress of 1891. If the long delay in the appearance of the present essay is in any measure responsible for its excellence, no one will regret that it did not appear on time. This is not the first piece of good work which Professor Van Hise has done; but he has done nothing which has been of greater utility to the geological world than the present volume will prove to be.

In no department of geology has there been more rapid progress during the last decade than in the department in which Professor Van Hise is a specialist. In no department is it more difficult for those who are not specialists to follow current progress. But so successfully has Professor Van Hise written his essay that the reader will have little difficulty in knowing the present status of pre-Cambrian geology in America. He may know definitely what is definitely known, and he may know definitely what is not known. More than this, he may know definitely the limitations and imperfections of facts and principles which are but partially worked out, without finding himself confused between fact and possible fact, or between established principles and unverified hypotheses. Consciously or unconsciously, the author has given definite shape to the uncertainties and indefinitenesses of his subject, and in so doing has rendered an invaluable service to students.

A mere summary of what has been done in the various areas of pre-Cambrian rocks would be valuable. But the present essay does much more. The author is personally familiar with much of the ground brought under review in the volume, and he has given, always without a suggestion of dogmatism, what every reader is glad to have, his own opinion concerning the interpretations to be placed on the phenomena of each of the regions with which he is familiar, together with the reasons therefor. The failure to summarize and interpret the summaries of the literature reviewed has lessened the value of some of the essays of this series.

The plan of the volume is simple. It consists of, first, a digest of all the papers on the pre-Cambrian geology of North America which had appeared at the time the manuscript left the author's hands; second, a discussion of the literature; and, third, a discussion of the general principles involved in the study of pre-Cambrian rocks, together with a statement of the results which have already been attained in America in the application of these principles.

The digests of the literatures are grouped on a geographical basis. The digest of all publications bearing on the pre-Cambrian geology of the original Laurentian and Huronian areas constitute one chapter, and the digests of the literature of the Lake Superior region, of the great northern area of Eastern Canada and Newfoundland, of the isolated areas in the Mississippi Valley, of the Cordilleras, and of the Eastern United States, constitute each a separate chapter. Within each area the digests are arranged chronologically. At the close of each chapter, or in some cases at the close of their subdivisions, are summaries of the results thus far attained in the respective areas. In all cases the digests appear to be as nearly absolutely impartial as it is possible for human work to be. The total number of papers summarized is between 700 and 800. Many of them are papers of considerable length, some of them being elaborate reports. When it is remembered that these papers are not roughly abstracted, but that carefully considered digests are presented, the amount of labor involved in the preparation of the bulletin will be apparent.

It is the final chapter which, together with the maps, will attract most attention. This chapter gives a concise outline history of the development of pre-Cambrian geology in America, and a clear exposition of its present status. Professor Van Hise concludes that it may be accepted as demonstrated that in North America there is an intricate system of granites and gneisses and crystalline schists, which represent the oldest rocks of the continent, and that this system underlies all known sedimentary rocks and their derivatives, and that if it ever contained sedimentary materials of any sort, all evidence of their existence has been obliterated.

It is to this system of rocks that the name Archean is restricted.

The minerals composing these rocks, wherever found, generally agree in showing evidence of extensive dynamic changes, as do also the relations of each sort of rock composing the system, to each other. So closely do the rocks of this system resemble each other in different regions, that Professor Van Hise says that a suite of specimens of Archean rocks from any one of the regions examined by him, if not labeled, "could by no possibility be asserted not to have come from any other." The system is a unit, both in its positive and negative characters.

To the Archean system thus defined are referred the basement complexes of Arizona, of the Wasatch Mountains, of certain ranges of Nevada, of Southwest Montana, of Texas, of the Lake Superior region, of the Hudson Bay region, probably the basement complex of Newfoundland, and much of the great area of Northern Canada, known as Laurentian. The basal complexes of the Front range, and of the Quartzite Mountains of Colorado, are referred to the Archean with less confidence. Still other areas not yet definitely classified may prove to be Archean in whole or in part.

With reference to the origin of the Archean, Professor Van Hise inclines to a modification of the theory that the system represents a part of the original crust of the earth. He believes that the Archean rocks were originally igneous, and that they may include not only such remnants of the pre-sedimentary crust as may exist, but those deeper parts of the crust which became lithified in later times, and which have reached the surface by denudations. He suggests that the banded and contorted granite-gneiss which serves as a background for the Archean may represent the rocks having such an origin, while the other parts of the system may be subsequent eruptives, assignable to no other system, and physically a part of the Archean.

The author does not overlook the fact that this suggestion concerning the origin of the Archean may make the system include rocks which crystallized below the outermost crust after sedimentation began, and that the date of this lithification may therefore be Algonkian, or even post-Algonkian. Their crystallization at such a date is not looked upon as sufficient reason for excluding them from the Archean group. It is manifestly impracticable to have an Algonkian system below the Archean, representing crystallization or lithification synchronous with the Algonkian sedimentation above.

This being the conception of the Archean, it is evident that stratigraphical methods are not applicable to it. The only division which seems applicable is a bifold one, based on lithological characters and relations, viz.: 1, the more schistose rocks, generally dark colored, and 2, the more massive rocks (granites and granite-gneisses), generally light colored. To the latter class it is proposed to restrict the name Laurentian. For the former class, the coördinate name Mareniscan is proposed, the term being derived from the name of a township (Marenisco) in Michigan.

The necessity for a group between the Archean and Cambrian has come to be generally recognized during the last decade. But to all except those engaged in the study of pre-Cambrian rocks, the names which have been used to designate this group, or parts of it, have always been confusing, because of their multiplicity, their lack of definition, and the lack of uniformity in their use. This bulletin makes clear the nomenclature which has been adopted by the survey, and sets forth the relation of the various names which have been used to designate parts of the post-Archean (as here used) and pre-Cambrian group. Whether or not those not connected with the survey agree that the nomenclature officially agreed upon is the best possible, it is to be hoped that it may be uniformly adopted in the interest of intelligibility. It has the merit of simplicity and definiteness, and of avoiding disputed questions, so far as this is possible.

To the post-Archean pre-Cambrian group is given the name *Agnotozoic*, or, preferably, since its fossils are becoming known *Proterozoic*, a term coördinate with Archean, Paleozoic, etc. Since it is impossible to divide this group into systems coördinate with Cambrian, Silurian, etc., which can be correlated with each other throughout the various areas of Proterozoic rock, the term Algonkian is used for the present as a single system term to cover the whole Proterozoic group. In many areas the group is distinctly divisible into two or three systems comparable with the Cambrian, Silurian, etc. Thus in the original Huronian area there are probably two unconformable series of rocks, the lower unconformable on the Archean, and the upper unconformable below the Cambrian. These may be correlated with some degree of confidence with the Lower and Upper Huronian of the Lake Superior region. But here a third series, the Keweenawan, intervenes between the Upper Huronian and the Cambrian, and is unconformable with both. In the Grand Cañon region again, three series are recognized. But their relation to the three series of the Lake

Superior region is not known. The same is true of other regions. For this reason, the various terms, Huronian, Keweenawan, Vishnu, Chuar, etc., which have been used to designate definite parts of the group, will still be retained, for in the absence of criteria for the satisfactory correlation of the subdivisions of the group in the various regions where they occur, these parts must continue to bear local names.

The group is so extensive as to be comparable in thickness to the Paleozoic, Mesozoic and Cenozoic combined, and inferentially to represent an equal lapse of time. It contains great systems, separated by great unconformities. Concerning the two unconformities in the systems in the Lake Superior region, those between the Lower and Upper Huronian and between the latter and the Keweenawan, Professor Van Hise says: "Each represents an interval of time sufficiently long to raise the land above the sea, to fold the rocks, to carry away thousands of feet of sediments, and to depress the land again below the sea. That is, each represents an amount of time which is perhaps as long as any of the periods of depositions themselves." In parts of the region the Lower Huronian is known to be unconformable on the Archean. In other parts the relations are unknown. This statement of the case gives some idea of the thickness of the group, as well as of its complexity and importance.

The delimitation of the Algonkian is theoretically easy, after the definitions of the Archean and Cambrian. It includes all pre-Cambrian sedimentary rocks, and their igneous equivalents. Although a great unconformity generally separates the two groups, helping to render their distinction clear, it is not always easy of recognition. Locally parts of the Algonkian have undergone such profound metamorphism at the hands of dynamic forces which affected the Archean as well, that they seem to be structurally one. In such cases it is believed that the apparent conformity is in reality apparent only, the original structural relations being obscured or even obliterated by the structures superinduced by dynamic forces on both series involved. Even where there is a common structure in rocks regarded as Archean and Algonkian, there is sometimes inherent evidence that one part of the rocks concerned is clastic, while similar evidence is wanting in the other.

Not the least instructive part of the volume is the discussion of the principles applicable to Algonkian stratigraphy. It would be useless to attempt to summarize this discussion, since it is as brief as is consistent with adequacy, in its original form. Suffice it to say that while, as applied to Paleozoic rocks, the value of lithological characters and structural relations are well understood, they have a somewhat different meaning and a greater relative value when applied to the pre-Cambrian formations. At the same time this application is more difficult.

One of the most valuable parts of the volume consists of the twelve maps, covering most of the areas where pre-Cambrian rocks are known or suspected. Nowhere else does Professor Van Hise succeed better in making the indefiniteness of our knowledge definite, than on the maps. On but two of the twelve maps does he represent Archean rocks, viz., on the maps covering the original Huronian area and its surroundings, and on the map of the Lake Superior region. Within the United States, Archean rocks are mapped in but three states — Minnesota, Wisconsin and Michigan. This does not mean that Archean rocks do not exist elsewhere, or that they are not known elsewhere, but that their areas elsewhere, so far as covered by the maps, have not been defined. Some of the areas which we have been accustomed to see represented as Archean on maps made before the Algonkian was differentiated, are now represented as "unclassified pre-Cambrian." Of this the Adirondack region may serve as an example. The maps tell us only that the rocks of this region may be Algonkian, or Archean, or both. In the text Professor Van Hise's opinion concerning the area may be found. This is to the effect that the Algonkian is certainly represented in the region, and Archean possibly, but that existing knowledge on the point is not sufficiently definite for cartographic representation. Other areas which have been mapped as Archean are represented simply as "unclassified partly or wholly crystalline rocks." Of the areas thus represented, the whole of the crystalline schist belt of the Appalachian region may serve as an example. The author's map does not even assert that these rocks, or any part of them, are pre-Cambrian. Here again we find the author's opinion in the text, where it is indicated that parts of this area are pre-Cambrian, while other extensive portions may, or may not be. Such pre-Cambrian areas as are known are not defined, and therefore cannot be represented on the maps.

Algonkian rocks find definite representation in more regions than the Archean. They appear upon the maps in Arizona, New Mexico, Utah, South Dakota, Minnesota, Iowa, Wisconsin, and Michigan. They are known, but their areas not defined, in various other localities.

The summaries of the several chapters, or their sections, the final chapter, and the maps, should serve as a text-book on pre-Cambrian geology for all advanced students in our universities. Not only will the best information available be thus put into their hands, but the whole treatment of the subject is such as give an intelligent insight into the methods of geology, and into the methods of science as well.

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